A Comparison of Nearshore Fish Sampling Gears in Oneida Lake, New York

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ABSTRACT

Sampling and assessment of nearshore fish communities is difficult due to the wide variety of habitats, substrates, and often complex structures. During the summers of 2005 and 2006, we conducted a comparison of ten different gear types, with the intent to develop a long-term sampling protocol of nearshore communities in Oneida Lake, NY. Gear types consisted of nine configurations of fyke nets and one seine. Fyke nets varied by frame size (large vs. small), mesh size (large vs. small), orientation (parallel vs perpendicular), and the inclusion/exclusion of wings. Summers were broken into two sampling periods, during which 2 different sites were chosen for each of three major substrate types (sandy, rocky, and muddy) for a total of six sites. Student's t-test indicated significantly higher species richness and total catch during sampling period two. However, few significant differences were observed in any net-to-net comparisons using Tukey's Honestly Significant Difference (HSD). Catches of key sport fishes, such as smallmouth bass and largemouth bass were significantly higher in smaller meshed nets. In order to maximize ease, efficiency and accuracy, we recommend assessments of nearshore communities take place in sampling period two, using a combination of perpendicularly set medium frame fyke nets, with both large and small mesh sizes. Additional species, not caught by fyke nets, can be supplemented by seining at all sites.

INTRODUCTION

Aquatic ecosystems are often comprised of distinct habitats, and fish are partitioned among these habitats based on ecological strategies and life history traits. Fish communities in large freshwater lakes are frequently broadly partitioned into offshore, pelagic assemblages and nearshore, littoral assemblages (Diana 1995). Assessments of freshwater fish communities often focus on one or a few key sport species or life stages, with sampling restricted to those habitats that support the target species. However, the dynamics of even a single species are sensitive to overall ecosystem function, which is dependent upon the complex interactions both within and among habitats and the communities they support. As fisheries management adopts ecosystem approaches, assessment programs will need to become more holistic in nature, encompassing the diversity of habitats and fish species that contribute to community function (Hughes and Noss1992).

Littoral zones of lakes are frequently characterized by a complex suite of habitats, and can range from open, shallow-sloping sandy substrates to steeper-sloping rock or cobble substrates to vegetation on soft substrates. Given the structural complexity of littoral habitats, they are not sampled effectively by gears commonly used in open water areas, such as trawls. Similarly, gears that may be effective at sampling open shoreline areas may not be practicable in vegetated areas. Littoral areas thus present unique sampling challenges when program goals are to obtain representative samples of the fish community.

A variety of gears have been used to sample littoral fishes, and published results confirm that obtaining representative samples can be problematic. Weaver et al. (1993) used beach seines, fyke nets and gill nets to sample littoral fishes in Lake Mendota, Wisconsin, and found gear-related differences in the relative proportions of samples represented by different species. They noted that fish assemblages caught in a single gear did not necessarily reflect the proportion of species suggested by combined catches from all gears. Fago (1998) compared seines and fyke nets in 19 Wisconsin lakes and concluded that a combination of gears was necessary to accurately characterize fish community composition. Bennett and Brown (1969) compared gill nets, fyke nets, seines and electrofishing in an Oklahoma reservoir and found that trap nets and electrofishing produced the highest species diversity, but that all gears exhibited a high degree of species or size selectivity. Ridenhour (1960) observed strong diel differences in seine collections. Selectivity of sampling gears depends on many factors including fish habitat preference, schooling and swimming behavior, fish size and life-stage (Hayes 1983; Hubert 1983; Fago 1997). Similarly, sampling requirements vary among lakes and even within a lake according to differing habitat types (Lester et al. 1996). Thus, knowledge of the effectiveness of different gears in sampling fish communities in nearshore habitats is critical designing and interpreting valid community assessments (Breen and Ruetz 2006).

Oneida Lake in New York State has been the site of a long-term indexing program focused on walleye (*Sander vitreum*) and its primary prey species yellow perch (*Perca flavescens)* (Mills et. al. 2006). Techniques developed for sampling have created an effective pelagic and benthic-monitoring program, but little attention has been paid to littoral fishes and their population dynamics. Recent environmental changes have increased suitable habitat for a larger array of littoral fishes in the lake, and littoral species such as the largemouth bass (*Micropterus salmoides)* and smallmouth bass (*M. dolomieau)* are becoming more important, not only in terms of the lake's ecology, but also its sport fisheries. As a result, efforts to develop a nearshore sampling program were initiated that included comparisons of gears commonly used in littoral sampling. We followed the approach recommended by Weaver et al. (1993) by using several types of gears and arrangements over a representative range of habitats. The objectives of this paper are to present the results of a two year study comparing sampling performance of fyke nets and beach seines in assessing nearshore fish communities. Our goals were to determine which gears maximized sampling efficiency as measured by catch-per-unit-effort (CPUE) and species diversity of catches. Specific comparisons are also presented for catches of centrarchid species, which were to be a focus of the new sampling program, including young-of-the-year largemouth and smallmouth bass and age 1 and older sunfish species. Three sizes of fyke nets were compared, with three different set configurations at six sites sampled twice during the summers of 2005-2006. Samples were collected using a beach seine concurrent with the fyke net sampling. Here we present comparisons of total catch, species diversity, and effectiveness at sampling centrarchids.

METHODS

Study Site -

Oneida Lake is a large (207 km^2), shallow, polymictic lake in central New York, with an average depth of 6.8 meters and a maximum depth of 16 meters (Mills et al. 1978). The lake has a total shoreline length of 88 km. Littoral habitats consist of a variety of sandy, rock/cobble, and softer mud/silt substrates. Recently, littoral habitats in Oneida Lake have exhibited expansion of submerged aquatic vegetation from depths of approximately 2.0 meters to 5.1 meters as a result of increases in water clarity due to reductions in phosphorous loading and the establishment of filter-feeding, non-native zebra mussels (Zhu et. al. 2006).

Sampling –

We sampled six sites along the lake's southwest shoreline that were representative of the typical range of substrates in Oneida's littoral habitats: sandy substrate; muddy substrate with extensive and diverse submerged aquatic vegetation, and rocky substrate (Figure 1). Each site was sampled with a beach seine and fyke nets twice each summer from 2005-2006. Early summer sampling (Sample Period 1) was conducted from the end of May through early July, and a second round of sampling (Sample Period 2) was conducted from mid-July through mid-August. All gear types and configurations were used at each site during each sample period in both years. The beach seine was 22.9 m in length with a mesh size of 6.4 mm. Each haul was started about 15 to 20m offshore, and the seine was pulled perpendicular into shore. Seine hauls were conducted during daylight hours, typically between 0800 and 1700. All fish captured were identified to species and a sub-sample of 25 of each species was measured (total length, mm).

Three fyke net designs were tested: a 0.9 m x 1.5 m frame fitted with 5 mm delta knotless mesh (hereafter referred to as the Small net); a 0.9 m x 1.5 m frame fitted with 12.7 mm delta knotless mesh (hereafter referred to as the Medium net); and a .5 m x 1.8 m frame fitted with 12.7 mm delta knotless mesh (hereafter referred to as the Large net). Fyke nets were set at depths just slightly deeper than frame height. Three different net deployment configurations were tested: parallel to shore, perpendicular to shore, and perpendicular to shore with wings extended (See Table 1 for net codes used in this paper). All nets were set in all configurations at each site during both sampling periods of both years. Fyke net sets were approximately 24-hours long. All fish captured were identified to species, counted and sub-samples of 25 fish per species were measured to the nearest mm.

Analyses –

Because our use of fixed sites violated the assumption of independent random samples in Analysis of Variance, we used repeated measures ANOVA to compare catches among gears (Maceina et al. 1994). Data were grouped by sample site and year to reduce analyses to the experimental unit (gear). Comparisons included total CPUE (all species total catch/fyke net set or seine haul), species richness (total number of species/set or haul), young-of-year largemouth and smallmouth bass CPUE (catch/set or haul), and age-1 and older sunfish CPUE (catch/set or haul). Because data were not normally distributed, we performed log-transformations ($\log_{10}$(catch+1)) prior to analyses. Catches of young-of-year yellow perch were highly variable (typically 0 with rare catches of several thousand), and were excluded from analyses of total catch as outliers. Similarly, a single catch of 3065 young-of-year brown bullhead (*Ameiurus nebulosus*) was excluded from catch analyses. Paired comparisons of catches from sampling periods one and two by individual gears were conducted using a Student's t-test, treating years as replicates (only total catch and species richness were analyzed by sample period). Multiple comparisons (all gears) within sampling periods were conducted using Tukey's Honestly Significant Difference (HSD) test, treating years as replicates. Young-of-year bass catches were only analyzed for period two, as few bass recruited into the gears during sample period one. In tables presenting statistical results, significance was determined by tests using log-transformed data, but differences are reported in untransformed units for ease of interpretation. Significance level for all tests was established at the $\alpha < 0.05$ level. All analyses were conducted using SAS JMP statistical software Sall and Lehman 1996).

Shannon-Weiner's diversity index (H) and Evenness (E_H) were calculated for additional assessment of the diversity of species sampled in gears. Shannon's diversity index was calculated as:

$$\mathbf{H= -\sum [(n_i/N)*ln\ (n_i/N);}$$

Where n_i is the number of an individual species caught in a sample and N is the total number of fish caught in the sample (Magurran, 1998; Begon et al, 1996). To measure evenness the used the equation:

$$\mathbf{E_H= H/lnS;}$$

Where H is the Shannon-Weiner index value and S is the total number of species in the sample. The total number of unique species in fyke-nets and seine hauls was compared.

RESULTS

A total of 8,599 fish were collected in 2005 and 15,461 in 2006. Catches were highly variable in all gears in both years. Total catch per set or haul ranged from 0 to 846 fish. Number of unique species per set or haul ranged from 0 to 18.

We found significant differences in both total catch and species richness between sampling periods (Tables 2-3). Catches were significantly higher in sampling period 2 in 7 out of 10 gear/gear configurations, and differences in non-significant comparisons also showed higher catches in sample period 2. Significantly more species per set/haul were observed in sample period 2 in 7 out of 10 gear/gear configurations, and the remaining differences also favored period 2. Parallel fyke net sets tended to show the smallest differences between sampling periods in terms of both catch and diversity.

High variability in catches resulted in few statistically significant differences among gears in total catch or diversity (Tables 4-7, Figures 2-5). Despite the lack of statistical differences, some patterns were evident. Perpendicular fyke net sets caught more fish per set than parallel sets in 17 of 18 comparisons in period 1, and 12 of 18 comparisons in period 2. Similarly, average number of species per set was higher in perpendicular sets in 7 of 18 comparisons in period 1, and 15 of 18 comparisons in period 2. The seine tended to produce higher catches and more species than parallel fyke net sets, but lower catches than perpendicular sets. The seine caught more species per haul than any fyke net configuration in 15 of 18 comparisons. No pattern was evident in total catch or diversity when comparing perpendicular catches of fyke nets with and without wings.

High variability in centrarchid catches also resulted in few statistically significant differences. No statistical differences were observed in age-1 and older sunfish catches among any gears during sample period and 2 (Tables 8-9, Figures 6-7). However, as with total catch and diversity comparisons, patterns were evident. Perpendicular fyke net sets caught more sunfish than parallel sets in 16 of 18 comparisons in period 1 and 13 of 18 comparisons in period 2. Fyke nets caught more sunfish than the seine in 15 of 18 comparisons across both sample periods. No pattern was evident in catches of sunfish in perpendicular fyke nets with and without wings. Young-of-year smallmouth bass catches were also highly variable, but tended to be higher in the small fyke net set perpendicular to shore and the seine (Table 10, Figure 8-9). Young-of year largemouth bass catches revealed more among gear differences, with 19 of 45 comparisons producing statistical differences (Table 11, Figures 10-11). Highest catches were observed in the small fyke net set perpendicular to shore and the seine.

The Shannon-Wiener index was higher in the fyke-nets (2.30) than in the seine (1.85). The Evenness index was also higher in the fyke-net than the seine at 0.69 compared to 0.609, respectively. These results illustrate the ability of the fyke-net to catch a greater and more evenly distributed number of species than the seine. In 2005, the fyke net caught 28 different species, 7 of which were not captured in seine samples, while the seine caught 20 different species, all of which were also captured by fyke nets. In 2006, the fyke net caught 28 different species, 1 unique; the seine captured 20 species, 3 of which were unique.

DISCUSSION

Our study assessed ten different sampling methods during two different seasons. We found strong evidence that sampling later in the growing season produces higher catch rates and more species diversity, but we observed few statistically significant differences in performance among gears within seasons. Despite our inability to detect statistical differences, our study revealed marked patterns in relative performance of fyke net configurations. Nets set parallel to shore tended to produce lower catches and fewer species than nets set perpendicular to shore. Similarly, the beach seine tended to produce higher catches and more species than fyke nets set parallel to shore. Our results reflect the high inherent variability in nearshore fish sampling gears, and are similar to other published comparisons. Fago (1998) observed higher catches in small fyke nets than seines, but differences were significant for only 26 of 59 species collected. He observed similar species diversity in both gears. Weaver et al. (1993) also reported differences, but did not specifically compare catch rates among gears. However, unlike our results, they reported 50% higher catches in fyke nets set parallel to shore compared to nets set perpendicular to shore. Bennett and Brown (1968) also reported large differences among various nearshore sampling gears, but noted that young-of-year fish catches were highest in small mesh fyke nets and seines, similar to our results.

Our strongest results were from comparisons between sampling periods. Catches were significantly higher and characterized by higher diversity during the late summer sampling period. This is likely because age-0 did not recruit to the gears until later in the season. Differences were particularly pronounced in catches of young-of-year smallmouth and largemouth bass. Based on these results, nearshore sampling programs that are designed to prioritize indexing of bass year class strength should be scheduled later in the growing season. Given that largemouth bass had only recruited into our smallest mesh gears by August of 2006, bass indexing programs might best be conducted in early fall. To further assess differences in the ability of large vs. small mesh sizes to capture young-of-the-year smallmouth and largemouth bass at different times of year, seasonal patterns in girth measurements could be used to create mesh selectivity curves for Oneida Lake (Kraft and Johnson 1993). Our results and those of previous studies suggest that a combination of gears is ideal, but fisheries assessments are often limited by logistical realities. When resources are limited, allocation of effort is often determined by efforts to maximize catch and diversity of samples. Although few significant differences were detectable in our study, we revealed patterns of higher total catches and species diversity in perpendicular fyke net sets. These results indicate that effort may be better allocated by sampling more sites with perpendicular sets as opposed to fewer sites with both perpendicular and parallel sets. Additionally, we saw little benefit to the use of wings in perpendicular sets, and deployment time of fyke nets can be shortened by not using wings. While we saw the highest catches in the large fyke net, sunfish were captured most efficiently in the medium net and the small net was the only fyke net that sampled young-of-year largemouth bass effectively. Species richness differed little among the fyke nets in perpendicular sets. While the seine produced high catches of young-of-year bass, total catches tended to be lower than in perpendicular fyke nets, and seines may add little additional information to a design that includes small fyke net sampling. Our results suggest that a program that used all three fyke net types set perpendicular to shore would produce similar results to one that also included parallel sets and seining.

Our assessments were focused on maximizing catch and species diversity, with centrarchids as an additional measure of the suitability of different sampling methods to achieve our objectives for an Oneida Lake sampling program. For studies designed to census total species richness of a system, or prioritize other species, different approaches may be more effective. The variability in nearshore sampling gears revealed by our and previous studies points to the need for continued, detailed assessments.

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Tables and Figures

Table 1. Net Codes: Short forms of the 9 gear types, configurations and the beach seine used in the study

	FRAME	MESH	ORIENTATION	WINGS
PaL	Large	Large	Parallel	No
PaM	Small	Large	Parallel	No
PaS	Small	Small	Parallel	No
PeL	Large	Large	Perpendicular	No
PeM	Small	Large	Perpendicular	No
PeS	Small	Small	Perpendicular	No
PeLW	Large	Large	Perpendicular	Yes
PeMW	Small	Large	Perpendicular	Yes
[illegible]	Small	Small	Perpendicular	Yes
	Beach seine			

Table 2. Results of Student's t-test comparisons of **species richness** as a function of **sample period** in nearshore samples during late summer in Oneida Lake, New York, 2005-2006. Repeated measures approach was utilized to control for variability related to site and year and reduce analysis to the experimental unit (sample period). Statistical analysis was conducted on log-transformed data ($Log_{10}(Catch+1)$), but differences are presented as untransformed data for ease of interpretation

Difference *Student's t*	**PaL P2**	**PaM P2**	**PaS P2**	**PeL P2**	**PeLW P2**	**PeM P2**	**PeMW P2**	**PeS P2**	**PeSW P2**	**SN P2**
PaL P1	-0.4 *NS*									
PaM P1		-1.0 *NS*								
PaS P1			**-2.5** ***P<0.05***							
PeL P1				**-2.2** ***P<0.05***						
PeLW P1					**-2.8** ***P<0.05***					
PeM P1						**-1.9** ***P<0.05***				
PeMW P1							**-1.8** ***P<0.05***			
PeS P1								-1.8 *NS*		
PeSW P1									**-1.6** ***P<0.05***	
SN P1										**-3.4** ***P<0.05***

Table 3. Results of Student's t-test comparisons of **total catch** as a function of **sample period** in nearshore samples during late summer in Oneida Lake, New York, 2005-2006.

Difference *Student's t*	PaL P2	PaM P2	PaS P2	PeL P2	PeLW P2	PeM P2	PeMW P2	PeS P2	PeSW P2	SN P2
PaL P1	-144.4 *NS*									
PaM P1		**-46.8** ***P<0.05***								
PaS P1			-17.5 *NS*							
PeL P1				**-230.5** ***P<0.05***						
PeLW P1					**-96.0** ***P<0.05***					
PeM P1						**-142.42** ***P<0.05***				
PeMW P1							**-68.2** ***P<0.05***			
PeS P1								-17.3 *NS*		
PeSW P1									**-43.6** ***P<0.05***	
SN P1										**-68.9** ***P<0.05***

Table 4. Results of Tukey's Honestly Significant **Difference** multiple comparisons of **species richness** in nearshore samples during early summer (**Sample Period 1**) in Oneida Lake, New York, 2005-2006.

Difference *HSD*	PaL	PaM	PaS	PeL	PeLW	PeM	PeMW	PeS	PeSW	SN
PaL	0	0.6 *NS*	0.5 *NS*	-0.7 *NS*	-0.4 *NS*	-0.2 *NS*	0.3 *NS*	-0.1 *NS*	-0.3 *NS*	-0.3 *NS*
PaM		0	-0.1 *NS*	-1.3 *NS*	-1.0 *NS*	-0.8 *NS*	-0.3 *NS*	-0.7 *NS*	-0.9 *NS*	-0.9 *NS*
PaS			0	-1.2 *NS*	-0.9 *NS*	-0.7 *NS*	-0.3 *NS*	-0.6 *NS*	-0.8 *NS*	-0.8 *NS*
PeL				0	0.3 *NS*	0.5 *NS*	0.9 *NS*	0.6 *NS*	0.3 *NS*	0.3 *NS*
PeLW					0	0.3 *NS*	0.7 *NS*	0.3 *NS*	0.1 *NS*	0.1 *NS*
PeM						0	0.4 *NS*	0.01 *NS*	-0.2 *NS*	-0.2 *NS*
PeMW							0	-0.3 *NS*	-0.6 *NS*	-0.6 *NS*
PeS								0	-0.3 *NS*	-0.3 *NS*
PeSW									0	0.0 *NS*
SN										0

Table 5. Results of Tukey's Honestly Significant Difference multiple comparisons of **species richness** in nearshore samples during late summer (**Sample Period 2**) in Oneida Lake, New York, 2005-2006.

Difference *HSD*	PaL	PaM	PaS	PeL	PeLW	PeM	PeMW	PeS	PeSW	SN
PaL	0	0.0 *NS*	-1.6 *NS*	-2.4 *NS*	**-2.8** ***P<0.05***	-1.7 *NS*	-1.2 *NS*	-1.5 *NS*	-1.5 *NS*	**-3.3** ***P<0.05***
PaM		0	-1.6 *NS*	-2.4 *NS*	-2.8 *NS*	-1.7 *NS*	-1.2 *NS*	-1.5 *NS*	-1.5 *NS*	-3.3 *NS*
PaS			0	-0.8 *NS*	-1.2 *NS*	-0.1 *NS*	0.4 *NS*	0.1 *NS*	0.1 *NS*	-1.8 *NS*
PeL				0	-0.3 *NS*	0.8 *NS*	1.3 *NS*	0.9 *NS*	0.9 *NS*	-0.9 *NS*
PeLW					0	1.1 *NS*	1.6 *NS*	1.3 *NS*	1.3 *NS*	-0.6 *NS*
PeM						0	0.5 *NS*	0.2 *NS*	0.2 *NS*	-0.2 *NS*
PeMW							0	-0.3 *NS*	-0.3 *NS*	-2.2 *NS*
PeS								0	0.0 *NS*	-1.8 *NS*
PeSW									0	-1.8 *NS*
SN										0

Table 6. Results of Tukey's Honestly Significant Difference multiple comparisons of **total catch** in nearshore samples during early summer (**Sample Period 1**) in Oneida Lake, New York, 2005-2006.

Difference *HSD*	PaL	PaM	PaS	PeL	PeLW	PeM	PeMW	PeS	PeSW	SN
PaL	0	4 *NS*	14.5 *NS*	-9.8 *NS*	-42.3 *NS*	-23.4 *NS*	-26.6 *NS*	-18.3 *NS*	0.8 *NS*	-4.8 *NS*
PaM		0	10.5 *NS*	-13.8 *NS*	-46.3 *NS*	-27.4 *NS*	-30.6 *NS*	-22.3 *NS*	-3.2 *NS*	-8.8 *NS*
PaS			0	-24.3 *NS*	-56.8 *NS*	-37.9 *NS*	-41.1 *NS*	-32.8 *NS*	-13.7 *NS*	-19.3 *NS*
PeL				0	-32.5 *NS*	-13.7 *NS*	-16.8 *NS*	-8.5 *NS*	10.6 *NS*	5 *NS*
PeLW					0	18.8 *NS*	15.7 *NS*	24 *NS*	43.1 *NS*	37.5 *NS*
PeM						0	-3.2 *NS*	5.2 *NS*	24.3 *NS*	18.7 *NS*
PeMW							0	8.3 *NS*	27.4 *NS*	21.8 *NS*
PeS								0	19.1 *NS*	13.5 *NS*
PeSW									0	-5.6 *NS*
SN										0

Table 7. Results of Tukey's Honestly Significant Difference multiple comparisons of **total catch** in nearshore samples during late summer (**Sample Period 2**) in Oneida Lake, New York, 2005-2006.

Difference *HSD*	PaL	PaM	PaS	PeL	PeLW	PeM	PeMW	PeS	PeSW	SN
PaL	0	101.7 *NS*	141.4 *NS*	-95.6 *NS*	6.2 *NS*	-21.4 *NS*	49.7 *NS*	108.8 *NS*	101.7 *NS*	70.8 *NS*
PaM		0	39.8 *NS*	-197.3 *NS*	-95.5 *NS*	-123.1 *NS*	-52.0 *NS*	7.2 *NS*	0.0 *NS*	-30.9 *NS*
PaS			0	**-237.0** ***P<0.05***	-135.3 *NS*	-162.8 *NS*	-91.8 *NS*	-32.6 *NS*	-39.8 *NS*	-70.7 *NS*
PeL				0	101.8 *NS*	74.2 *NS*	145.3 *NS*	204.4 *NS*	197.3 *NS*	166.3 *NS*
PeLW					0	-27.6 *NS*	43.5 *NS*	102.7 *NS*	95.5 *NS*	64.6 *NS*
PeM						0	71.1 *NS*	130.3 *NS*	123.1 *NS*	92.2 *NS*
PeMW							0	59.2 *NS*	52.0 *NS*	21.1 *NS*
PeS								0	-7.2 *NS*	-38.1 *NS*
PeSW									0	-30.1 *NS*
SN										0

Table 8.
Results of Tukey's Honestly Significant Difference multiple comparisons of **age-1 and older sunfish** in nearshore samples during early summer (**Sample Period 1**) in Oneida Lake, New York, 2005-2006.

Difference *HSD*	PaL	PaM	PaS	PeL	PeLW	PeM	PeMW	PeS	PeSW	SN
PaL	0	-1.9 *NS*	14.3 *NS*	-7.9 *NS*	-31.6 *NS*	-26.0 *NS*	-16.6 *NS*	9.8 *NS*	11.5 *NS*	18.5 *NS*
PaM		0	16.2 *NS*	-6.0 *NS*	-29.7 *NS*	-24.1 *NS*	-14.7 *NS*	-11.8 *NS*	-13.5 *NS*	-20.4 *NS*
PaS			0	-22.2 *NS*	-45.8 *NS*	-40.3 *NS*	-30.8 *NS*	-4.4 *NS*	-2.8 *NS*	4.25 *NS*
PeL				0	-23.7 *NS*	-18.1 *NS*	-8.7 *NS*	17.8 *NS*	19.4 *NS*	26.4 *NS*
PeLW					0	5.6 *NS*	15.0 *NS*	41.4 *NS*	43.1 *NS*	50.1 *NS*
PeM						0	9.4 *NS*	35.8 *NS*	37.5 *NS*	44.5 *NS*
PeMW							0	26.4 *NS*	28.1 *NS*	35.1 *NS*
PeS								0	1.7 *NS*	8.7 *NS*
PeSW									0	7 *NS*
SN										0

Table 9. Results of Tukey's Honestly Significant Difference multiple comparisons of **age-1 and older sunfish** in nearshore samples during late summer (**Sample Period 2**) in Oneida Lake, New York, 2005-2006

Difference *HSD*	PaL	PaM	PaS	PeL	PeLW	PeM	PeMW	PeS	PeSW	SN
PaL	0	-14.8 *NS*	29.8 *NS*	-18.2 *NS*	-42.8 *NS*	-49.8 *NS*	-11.1 *NS*	18.8 *NS*	10.8 *NS*	18.6 *NS*
PaM		0	44.5 *NS*	-3.4 *NS*	-28.0 *NS*	-35.0 *NS*	3.7 *NS*	33.5 *NS*	25.6 *NS*	33.3 *NS*
PaS			0	-47.9 *NS*	-72.5 *NS*	**-79.5** ***P<0.05***	-40.8 *NS*	-11.0 *NS*	-18.9 *NS*	-11.2 *NS*
PeL				0	-24.5 *NS*	-31.6 *NS*	7.1 *NS*	36.9 *NS*	29.0 *NS*	36.8 *NS*
PeLW					0	-7.0 *NS*	31.7 *NS*	61.5 *NS*	53.6 *NS*	61.3 *NS*
PeM						0	38.7 *NS*	68.5 *NS*	60.6 *NS*	68.3 *NS*
PeMW							0	29.8 *NS*	21.9 *NS*	29.7 *NS*
PeS								0	-7.9 *NS*	-0.2 *NS*
PeSW									0	7.8 *NS*
SN										0

Table 10. Results of Tukey's Honestly Significant Difference multiple comparisons of **age-0 smallmouth bass** in nearshore samples during late summer (**Sample Period 2**) in Oneida Lake, New York, 2005-2006.

Difference *HSD*	PaL	PaM	PaS	PeL	PeLW	PeM	PeM W	PeS	PeS W	SN
PaL	0	2.3 *NS*	-8.8 *NS*	-44.4 *NS*	-21.2 *NS*	0.7 *NS*	0.1 *NS*	-19.5 *NS*	-24.8 *NS*	-9.3 *NS*
PaM		0	-11.1 *NS*	-46.7 *NS*	-23.4 *NS*	-1.6 *NS*	-2.2 *NS*	**-21.8** ***P<0.05***	-27.1 *NS*	-11.6 *NS*
PaS			0	-35.6 *NS*	-12.3 *NS*	9.5 *NS*	8.9 *NS*	-10.7 *NS*	-16.0 *NS*	-0.5 *NS*
PeL				0	23.3 *NS*	45.1 *NS*	44.5 *NS*	24.9 *NS*	19.6 *NS*	35.1 *NS*
PeLW					0	21.8 *NS*	21.3 *NS*	1.7 *NS*	-3.7 *NS*	11.8 *NS*
PeM						0	-0.6 *NS*	-20.2 *NS*	-25.5 *NS*	-10.0 *NS*
PeMW							0	**-19.6** ***P<0.05***	-24.9 *NS*	-9.4 *NS*
PeS								0	-5.3 *NS*	10.2 *NS*
PeSW									0	15.5 *NS*
SN										0

Table 11. Results of Tukey's Honestly Significant Difference multiple comparisons of **age-0 largemouth bass** in nearshore samples during late summer (**Sample Period 2**) in Oneida Lake, New York, 2005-2006.

Difference *HSD*	**PaL**	**PaM**	**PaS**	**PeL**	**PeLW**	**PeM**	**PeMW**	**PeS**	**PeSW**	**SN**
PaL	0	0.9 *NS*	**-7.9** ***P<0.05***	0.7 *NS*	0.3 *NS*	0.3 *NS*	0.6 *NS*	**-15.8** ***P<0.05***	-5.8 *NS*	**-10.4** ***P<0.05***
PaM		0	**-8.8** ***P<0.05***	-0.3 *NS*	-0.7 *NS*	-0.6 *NS*	-0.3 *NS*	**-16.7** ***P<0.05***	**-6.8** ***P<0.05***	**-11.3** ***P<0.05***
PaS			0	**8.6** ***P<0.05***	**8.2** ***P<0.05***	**8.3** ***P<0.05***	**8.5** ***P<0.05***	-7.8 *NS*	2.1 *NS*	-2.5 *NS*
PeL				0	-0.4 *NS*	-0.3 *NS*	-0.1 *NS*	**-16.4** ***P<0.05***	-6.5 *NS*	**-11.1** ***P<0.05***
PeLW					0	0.1 *NS*	0.3 *NS*	**-16.0** ***P<0.05***	-6.1 *NS*	**-10.7** ***P<0.05***
PeM						0	0.3 *NS*	**-16.1** ***P<0.05***	-6.2 *NS*	**-10.8** ***P<0.05***
PeMW							0	**-16.3** ***P<0.05***	-6.4 *NS*	**-11.0** ***P<0.05***
PeS								0	9.9 *NS*	5.3 *NS*
PeSW									0	-4.6 *NS*
SN										0

Fig. 1. Map of the location of Oneida Lake, NY, and a description of the six sampling sites used for the study

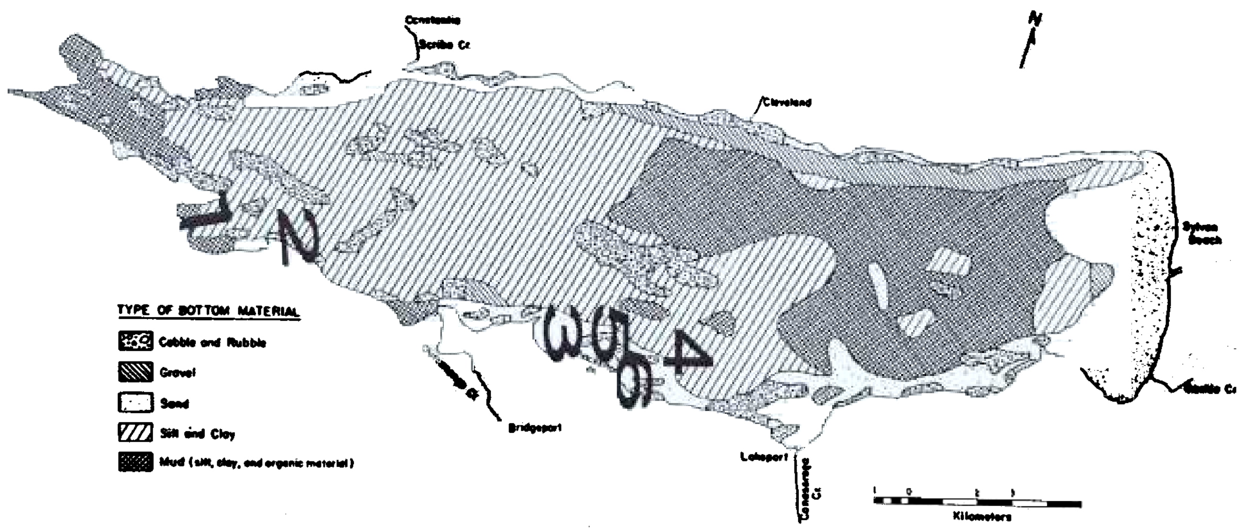


Fig. 16. Bottom sediments categorized on the basis of composition and size of materials in Oneida Lake. After Greeson (1971).

Sites Sampled:

1 Lower South Bay – Muddy Substrate

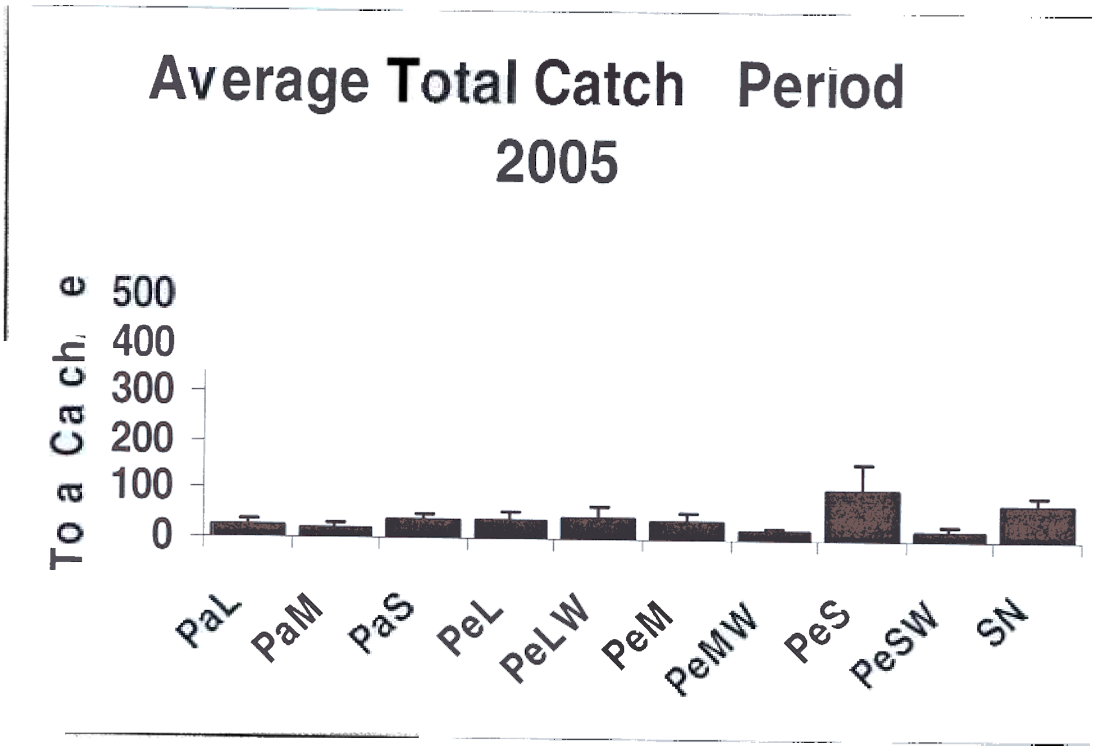
2 Norcross Point – Rock Substrate

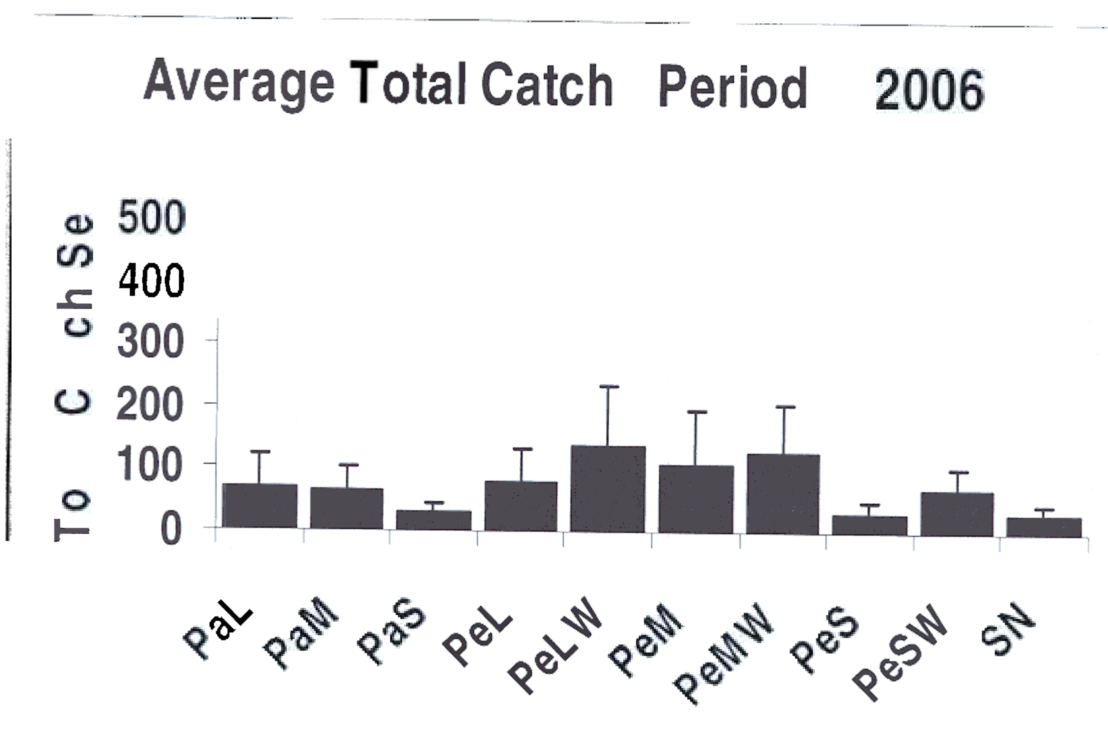
3 Billington Bay – Sandy Substrate

4 Dutchman's Island – Muddy

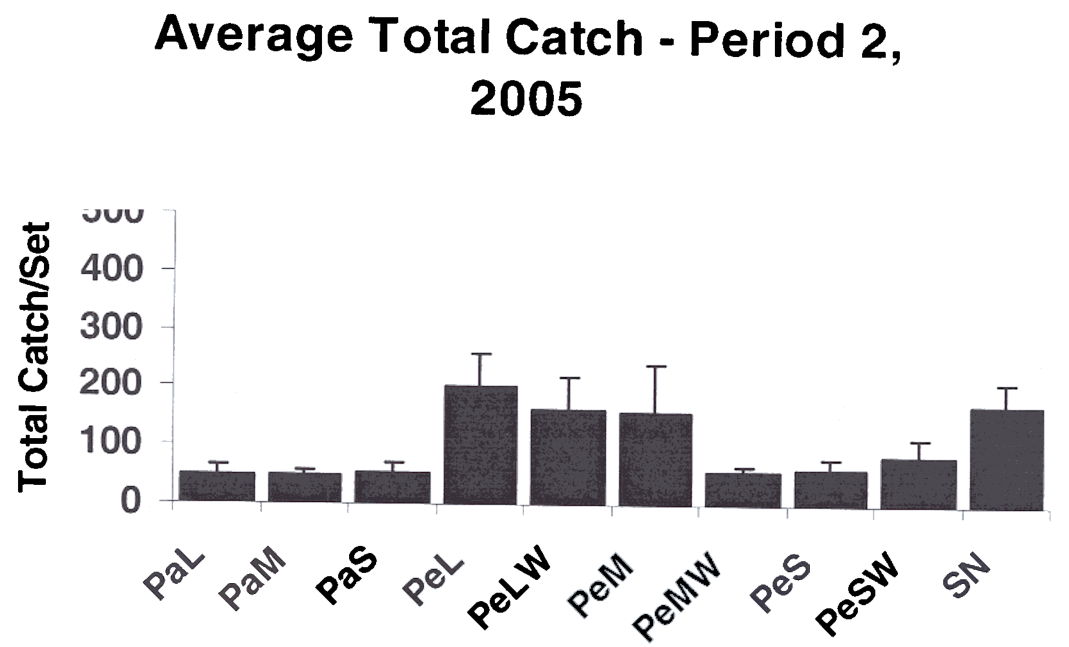
5 Shackleton Point Poker Cabin – Rock

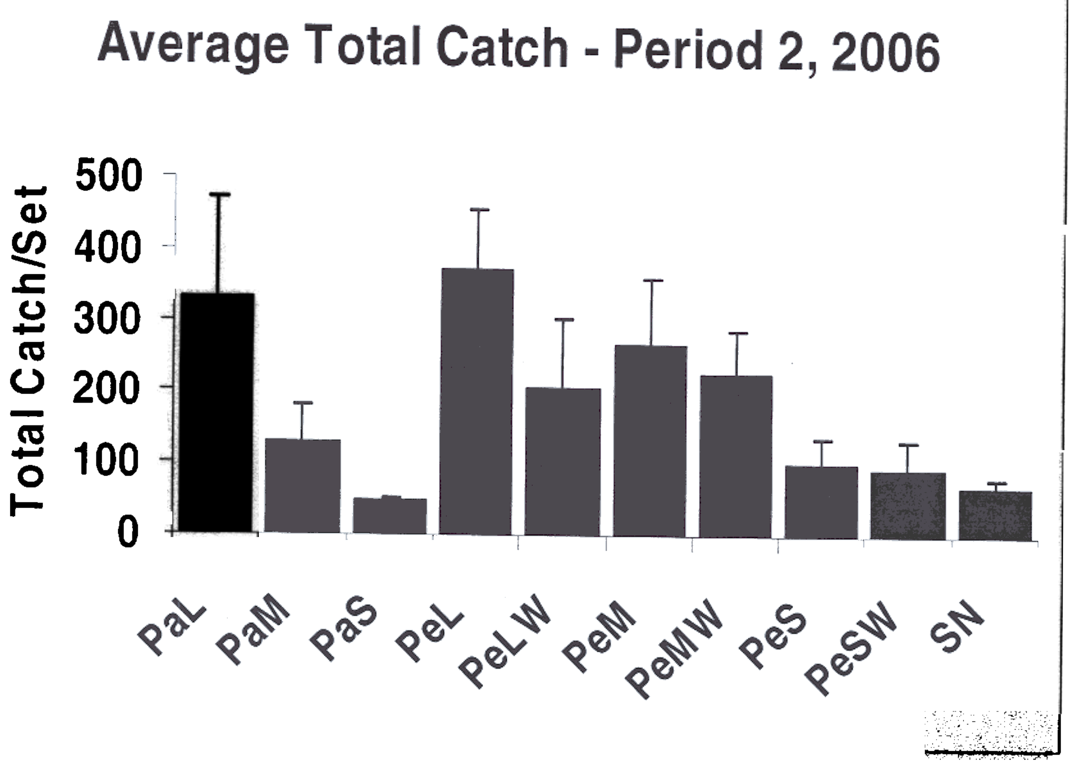
6 Shackleton Point Swimming Area –Sand



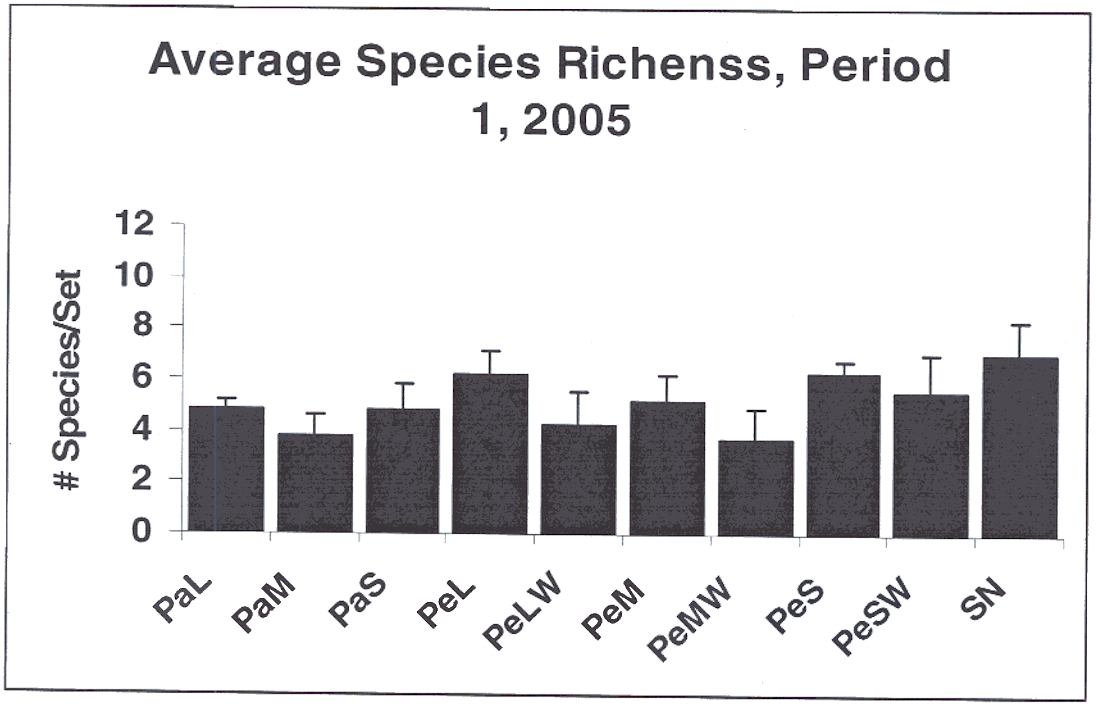


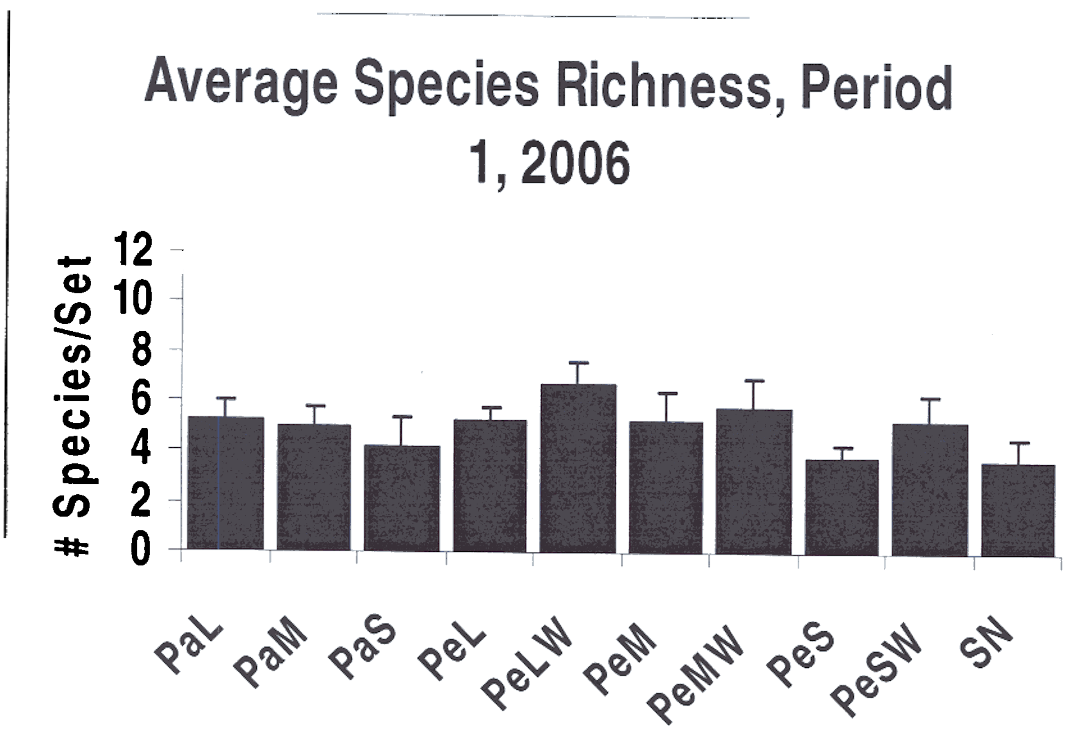
Figures 2a & Average total catch for period 2005 and 2006



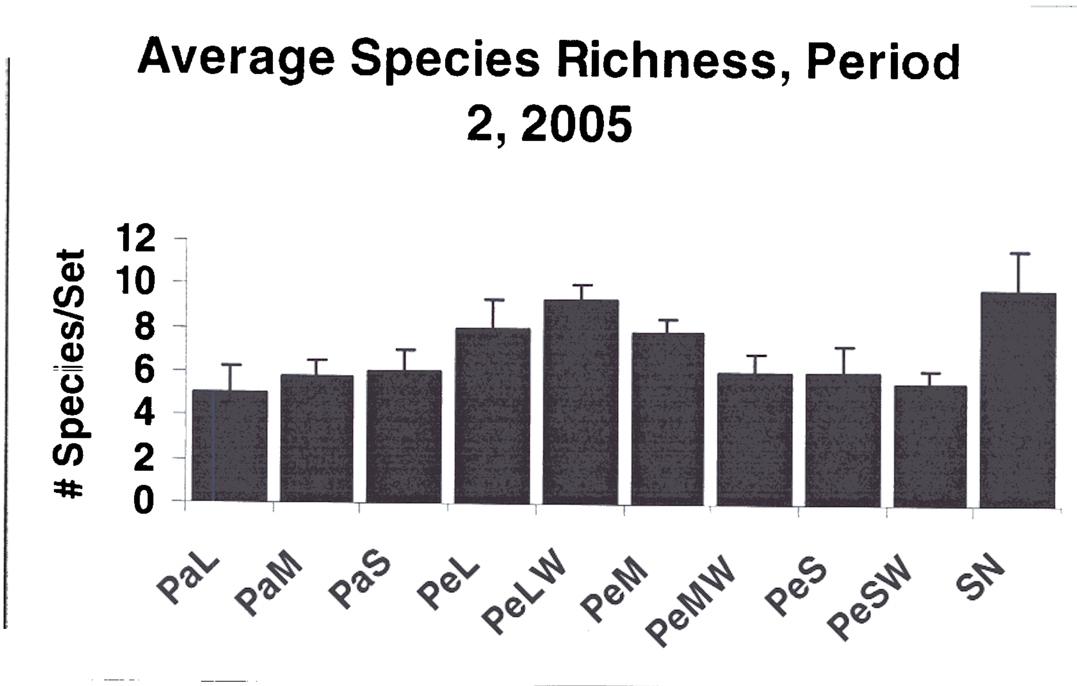


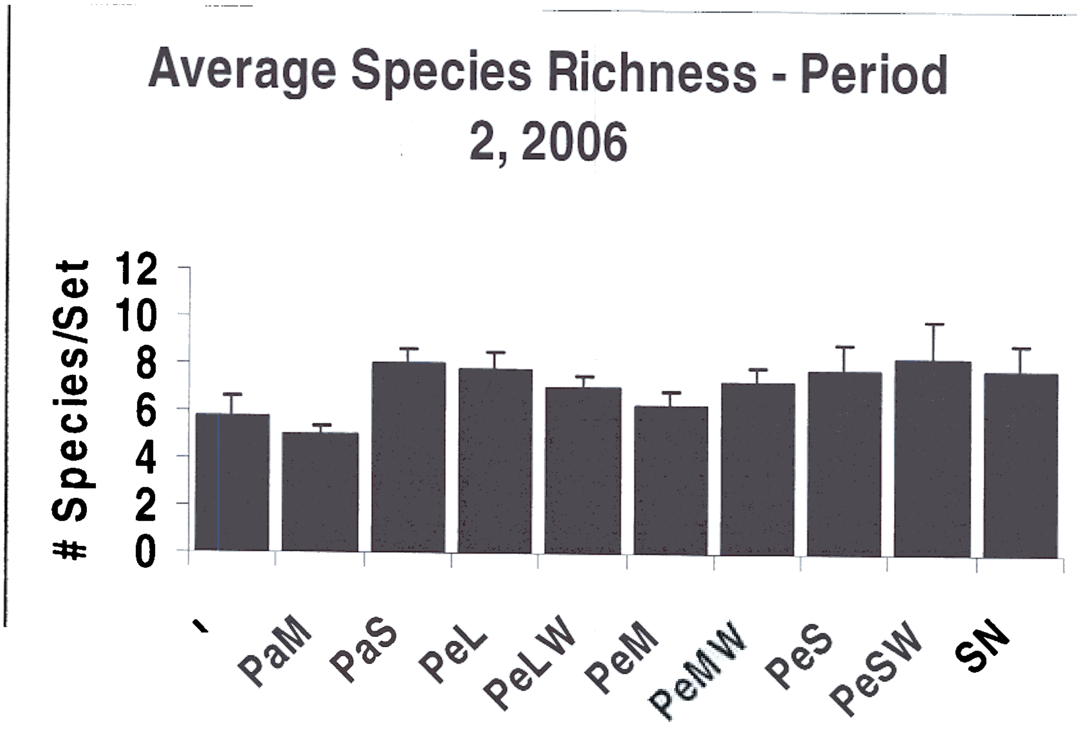
Figures 3a & 3b. Average total catch for period 2 in 2005 and 2006.



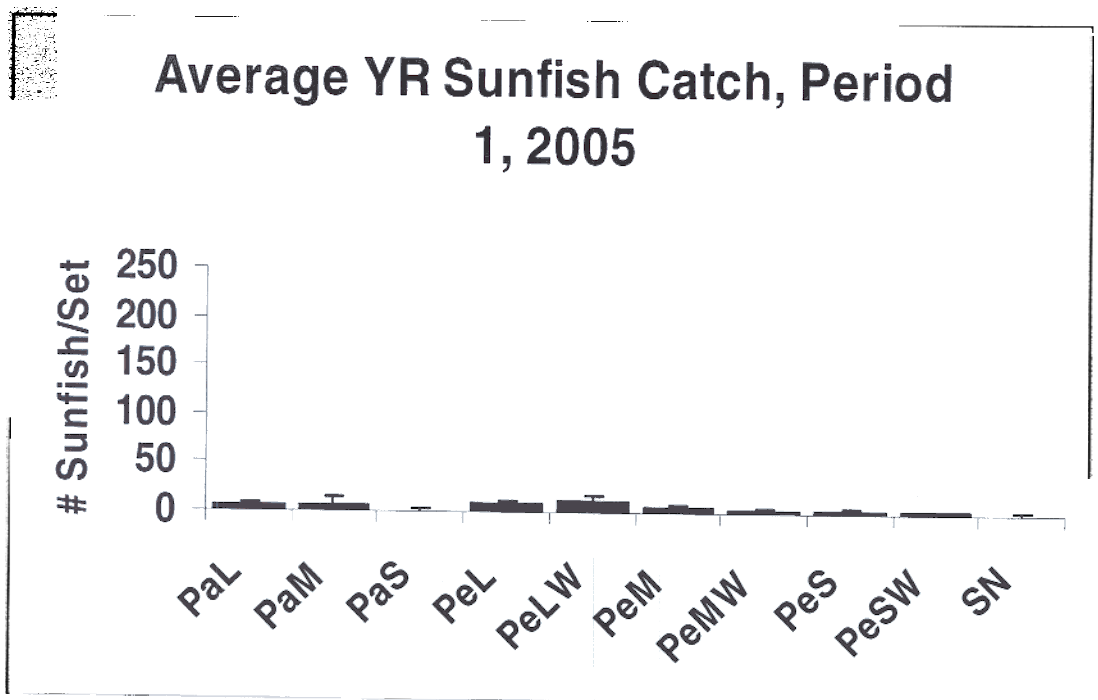


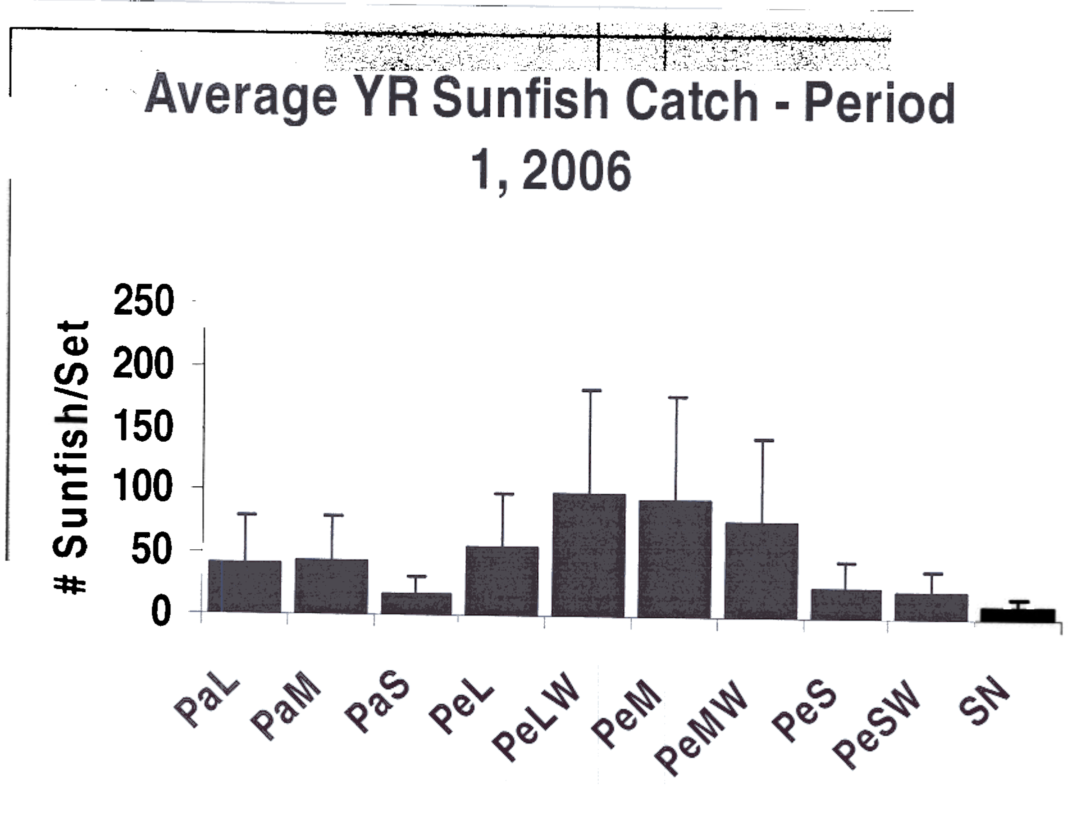
Figures 4a & 4b. Average species richness during period for 2005 and 2006



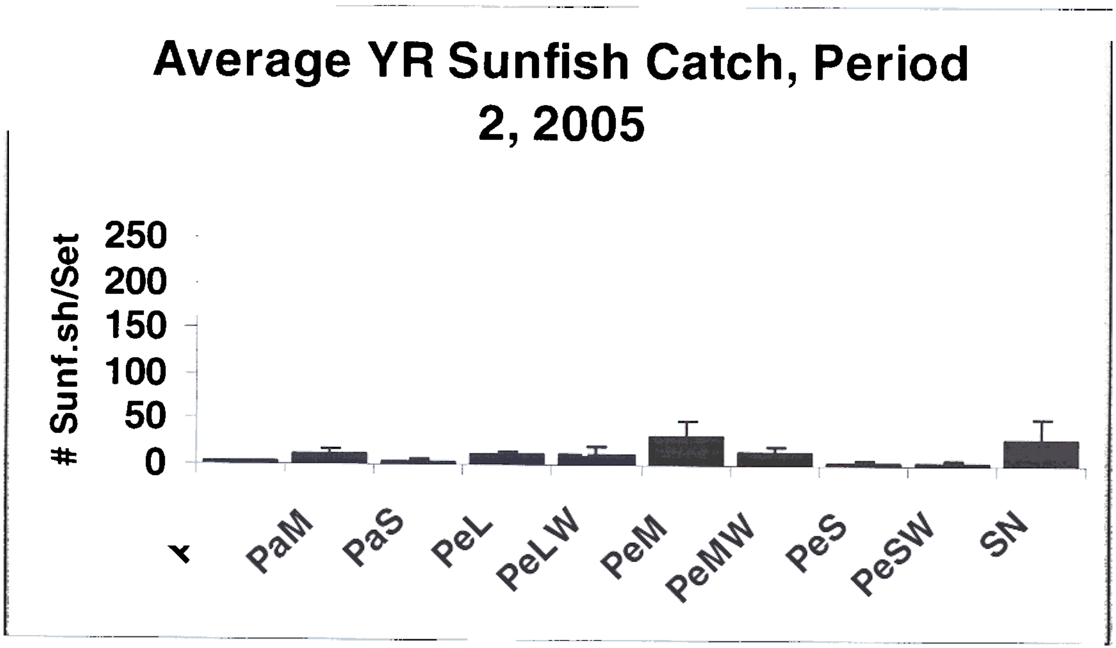


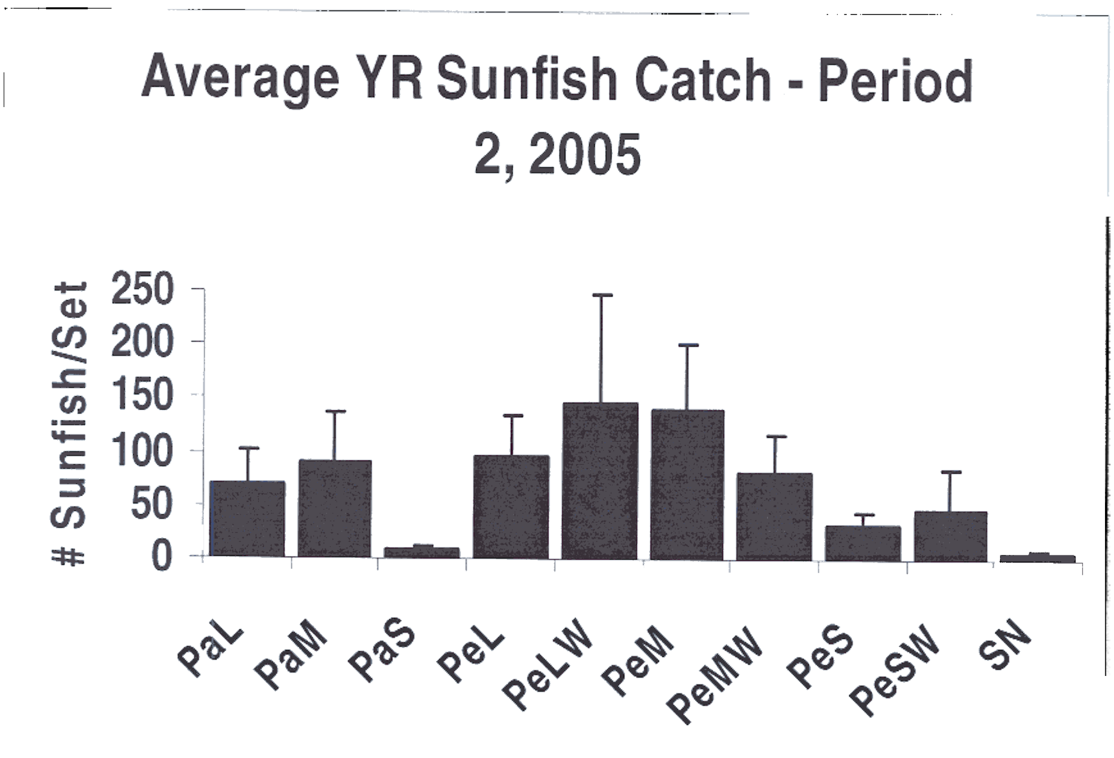
Figures 5a & 5b. These figures represent the average species richness per net during period 2 during 2005 and 2006.



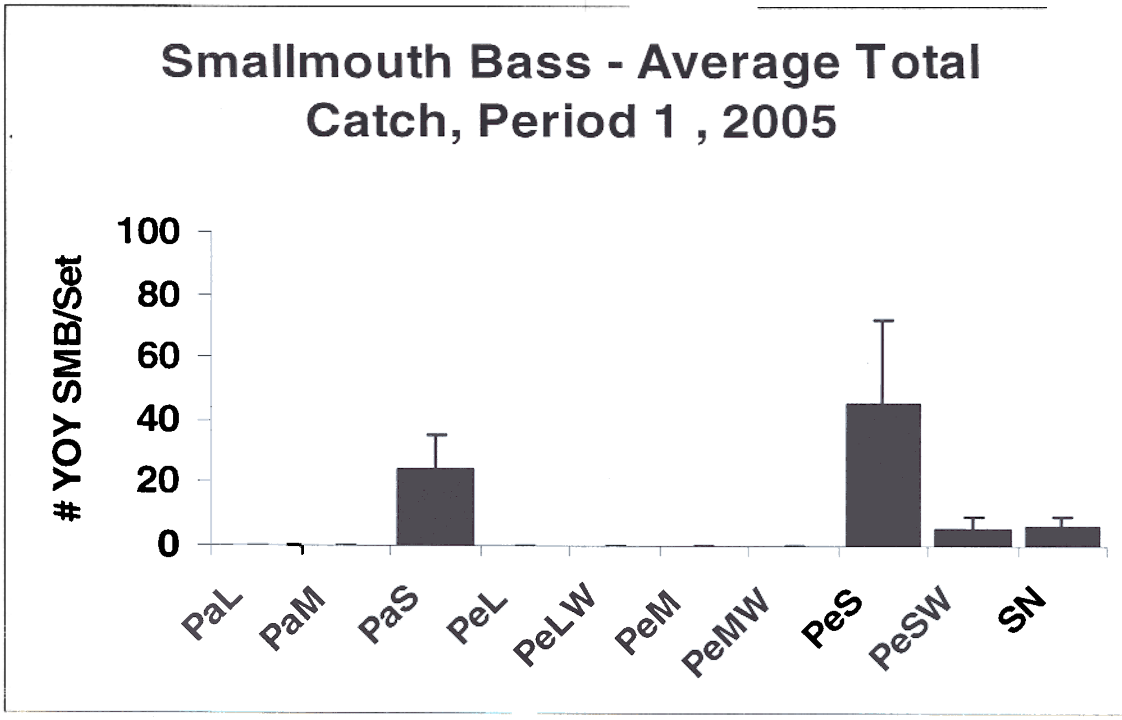


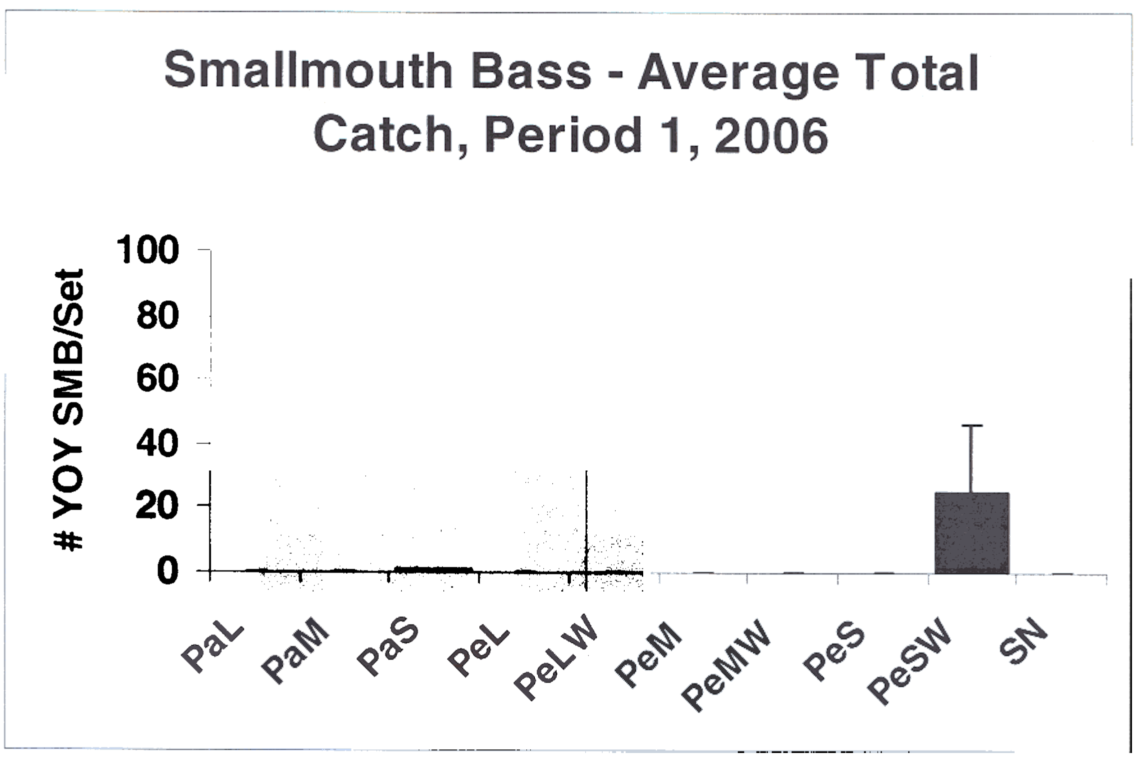
Figures 6a & 6b. Average Age-1 and older Sunfish caught during period one in 2005 and 2006.



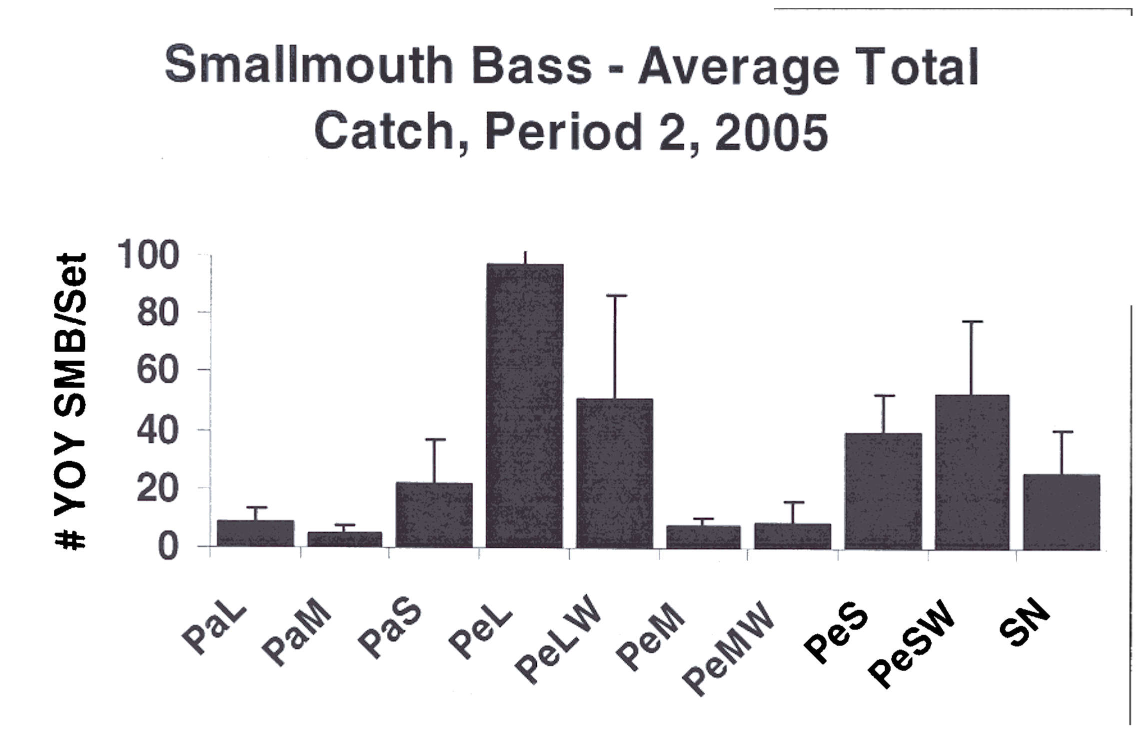


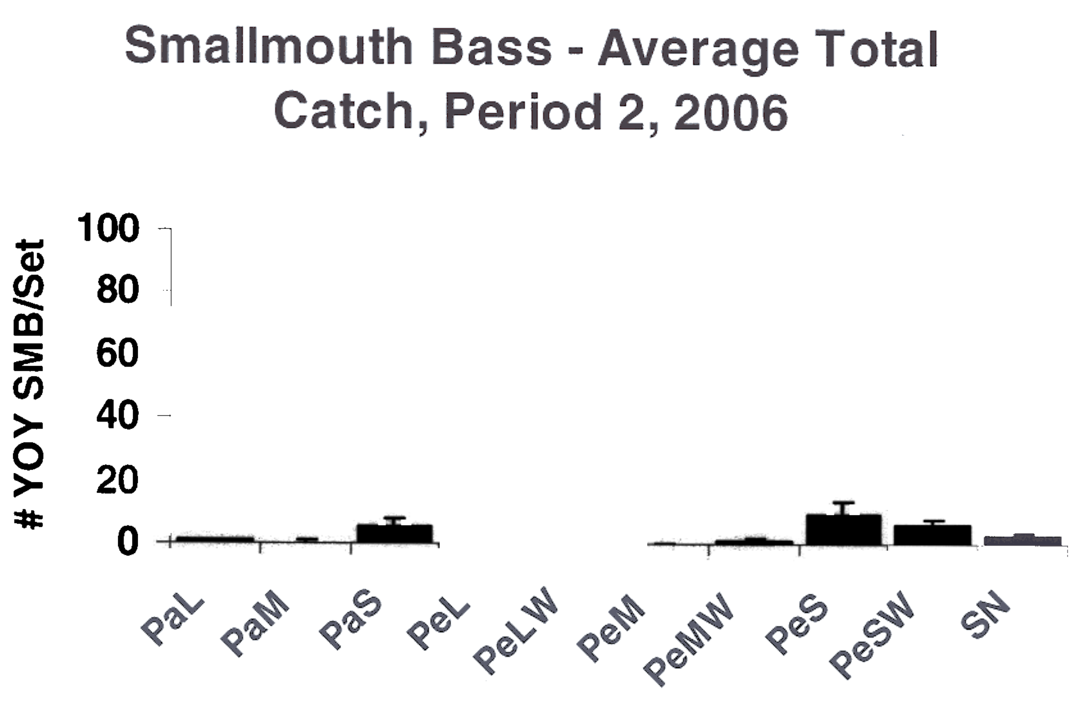
Figures 7a & 7b. Average Age-1 and older Sunfish caught during period two in 2005 and 2006.



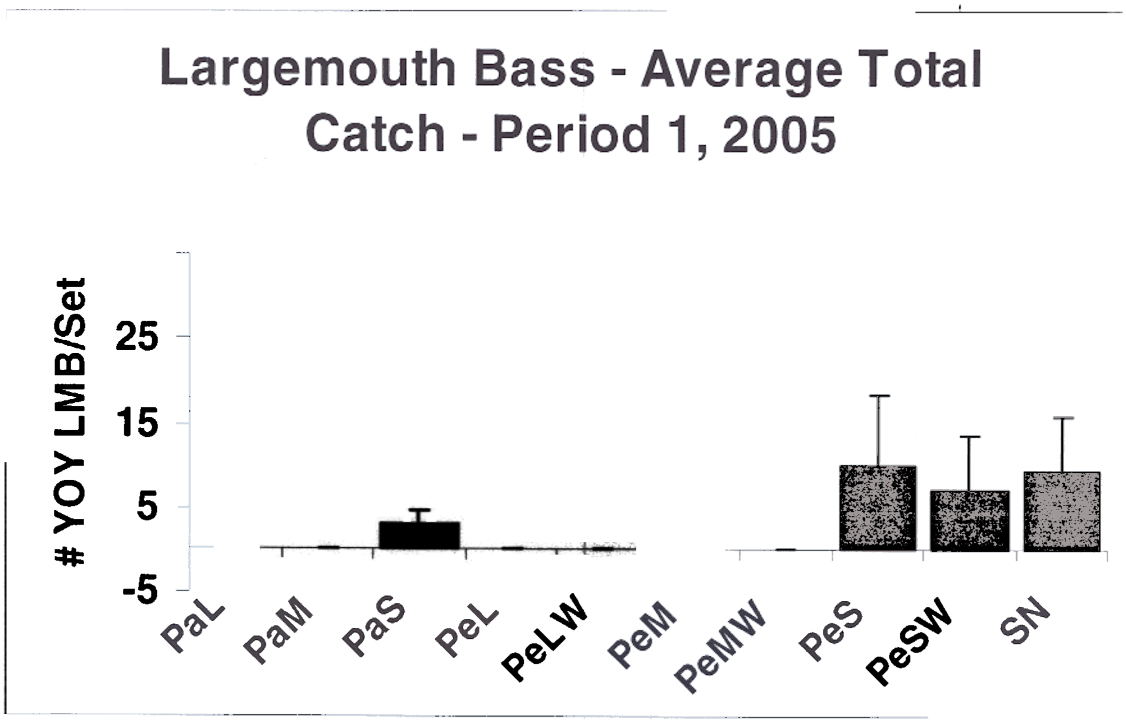


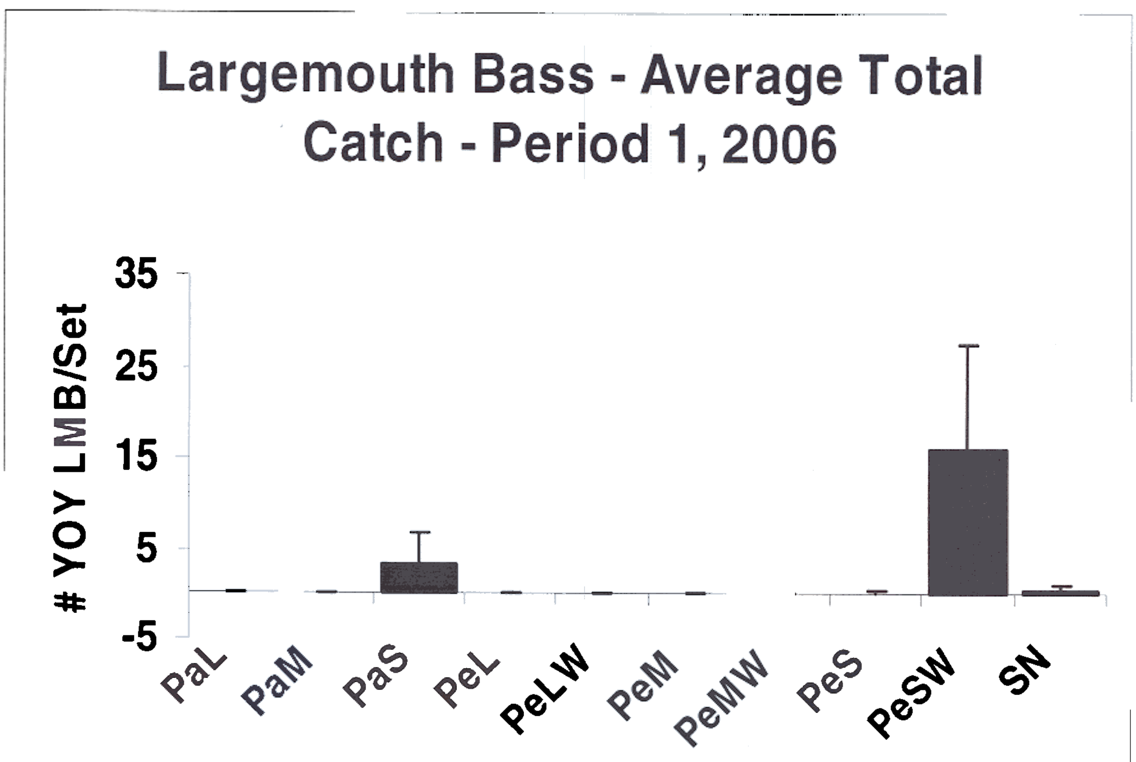
Figures 8a & 8b. Average YOY Smallmouth bass catch during period one in the summers of 2005 and 2006



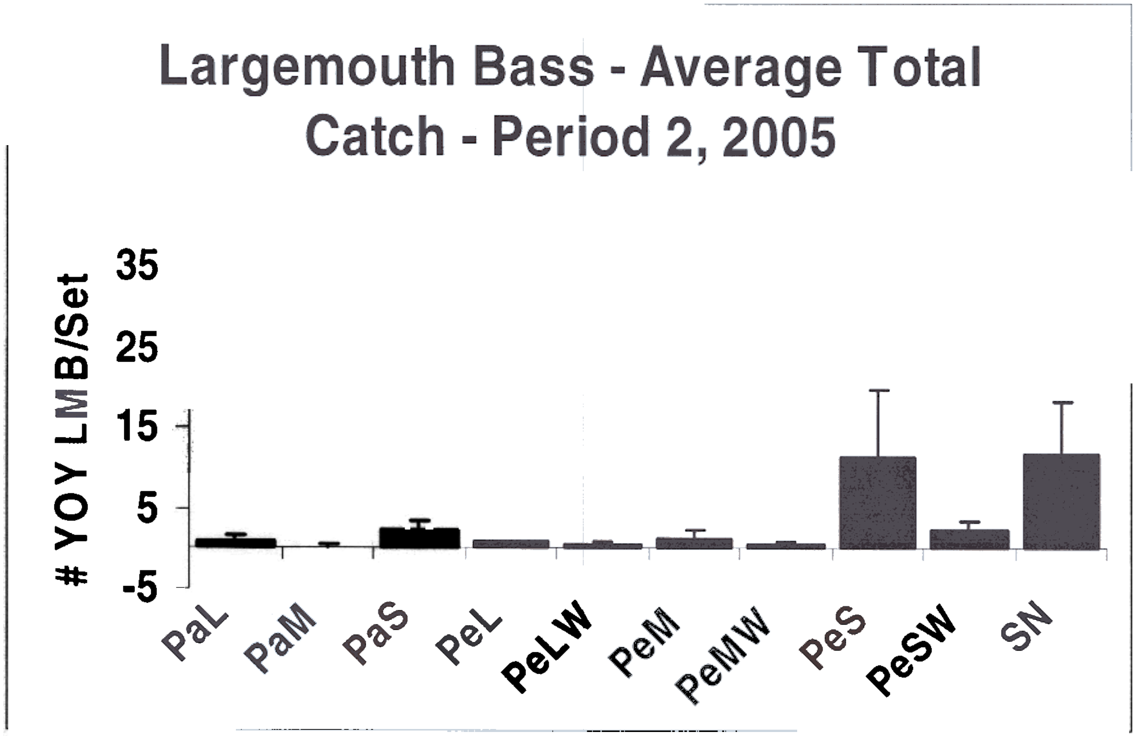


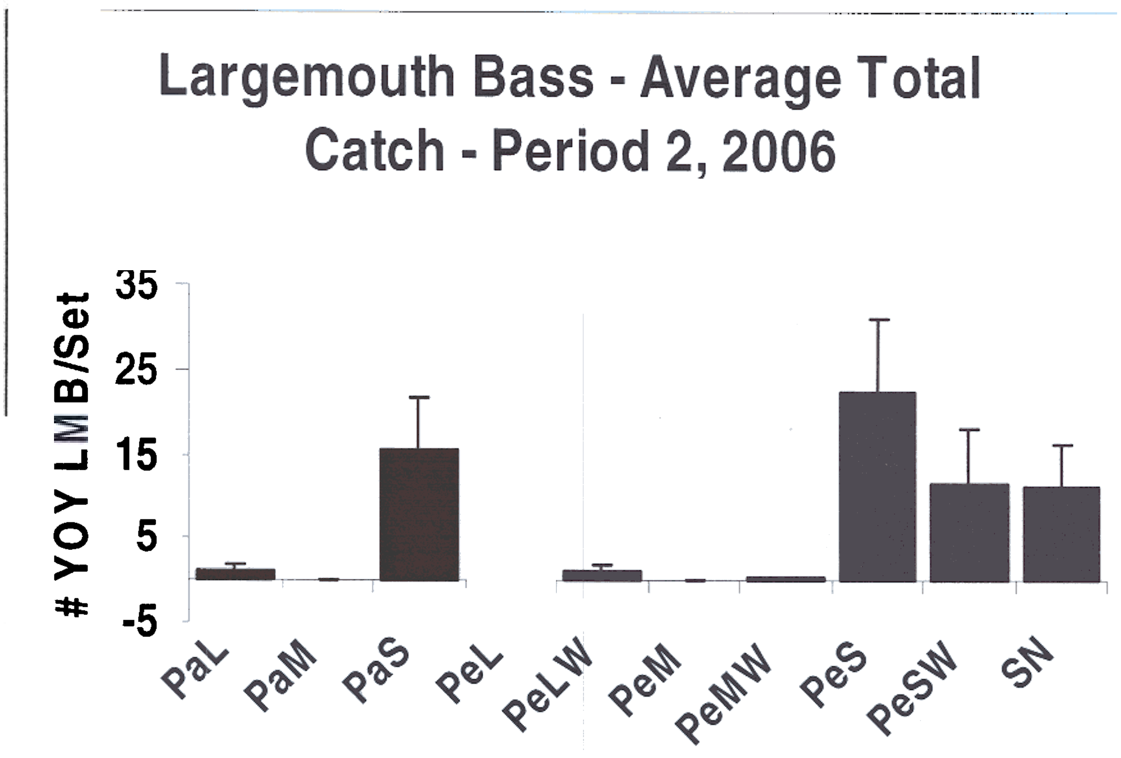
Figures 9a & 9b. These two figures represent YOY Smallmouth bass catch during period two in 2005 and 2006.





Figures 10a & 10b. Average YOY largemouth bass catch during period one in 2005 and 2006.





Figures 11a & 11b. These two figures represent the average YOY largemouth bass catch during period two in the summer of 2005 and 2006.